Design of a Wideband LNA for Human Body Communication

Maicon D. Pereira and Fernando Rangel de Sousa
maicondeivid@ieee.org, rangel@ieee.org

Radio Frequency Integrated Circuits Group - GRF
Federal University of Santa Catarina - UFSC

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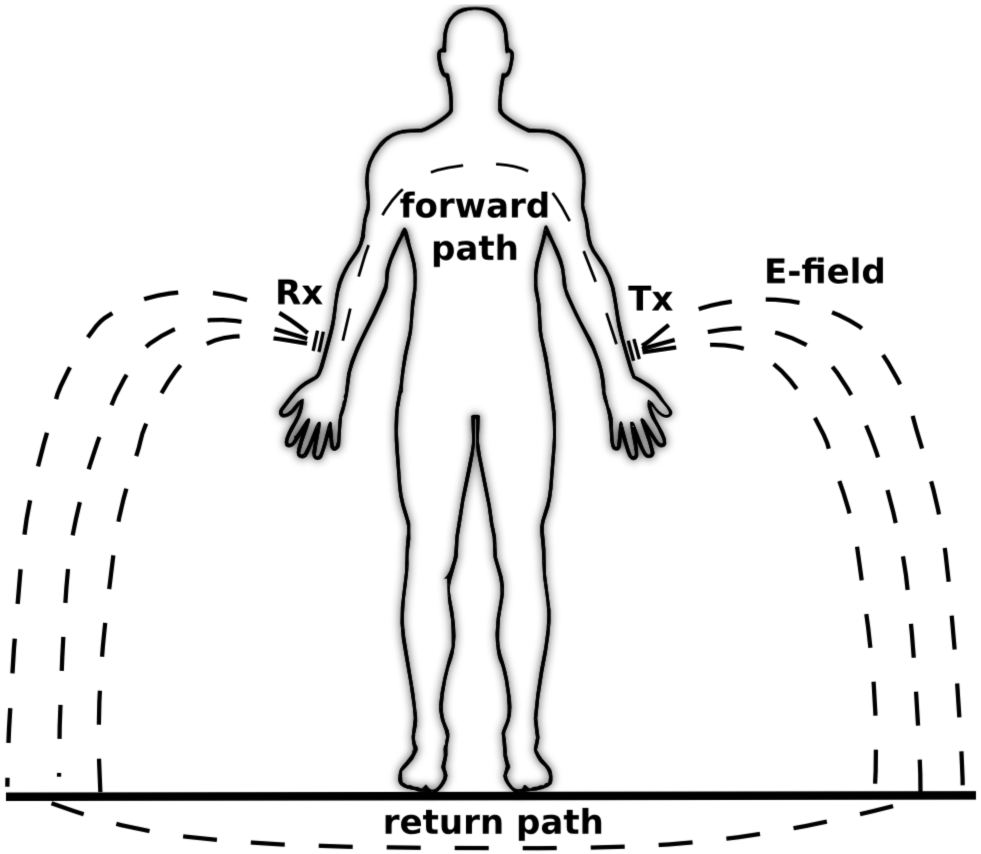
PRESENTATION OUTLINE

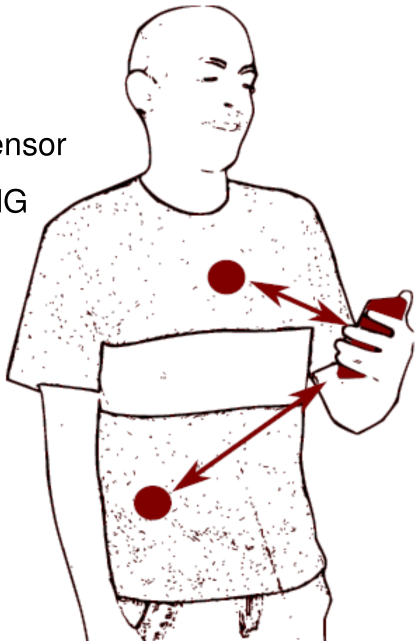
- Human Body Communication
- Noise canceling technique
- Circuit design
- Simulations
- Conclusion

HUMAN BODY COMMUNICATION

- Electric field coupling
- Operates below 100MHz
- Low interference
- High security
- Low power
- Application in general BANs

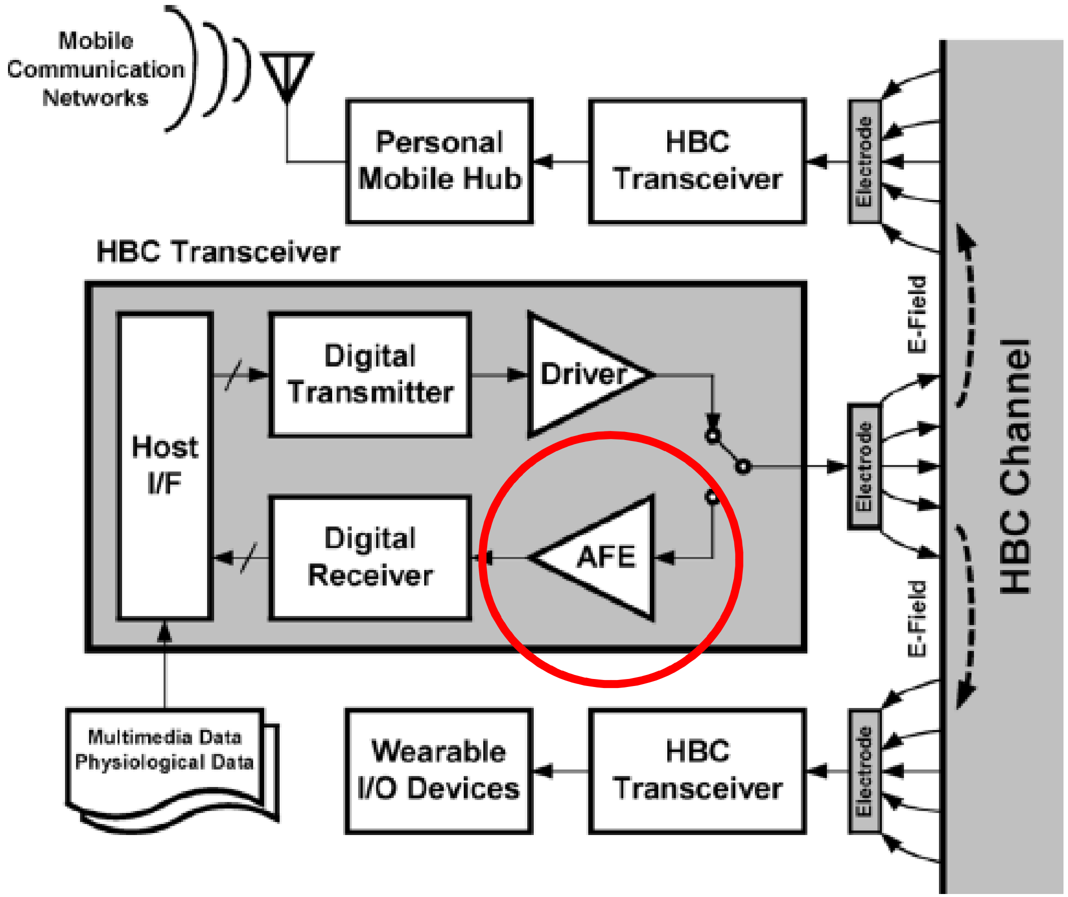


- Temperature sensor
- ECG, EEG, EMG
- Motion sensor
- Hearing aid
- Identification
- Media player



HBC TRANSCEIVER

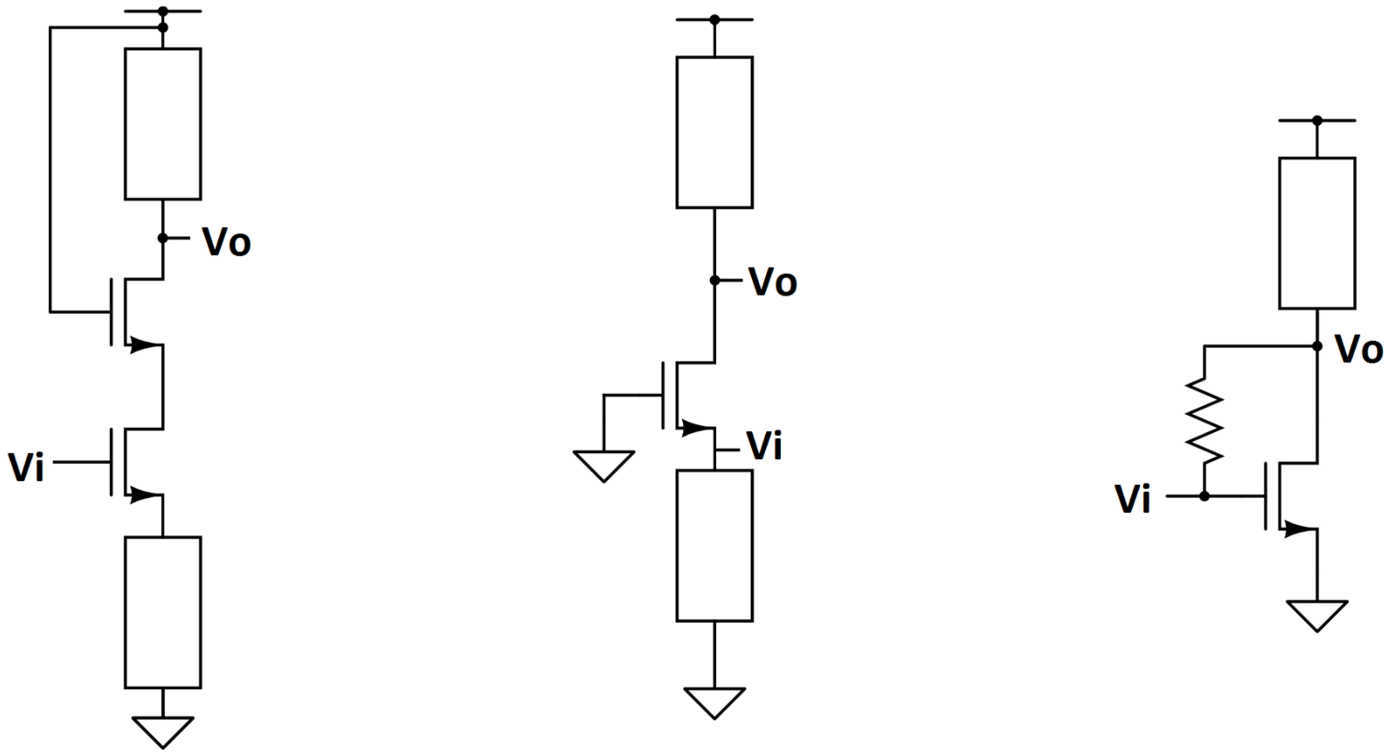
- Digital transceiver.



Seong-Jun Song; Namjun Cho; Hoi-Jun Yoo, "A 0.2-mW 2-Mb/s Digital Transceiver Based on Wideband Signaling for Human Body Communications," Solid-State Circuits, IEEE Journal of , vol.42, no.9, pp.2021,2033, Sept. 2007

LNA TOPOLOGIES

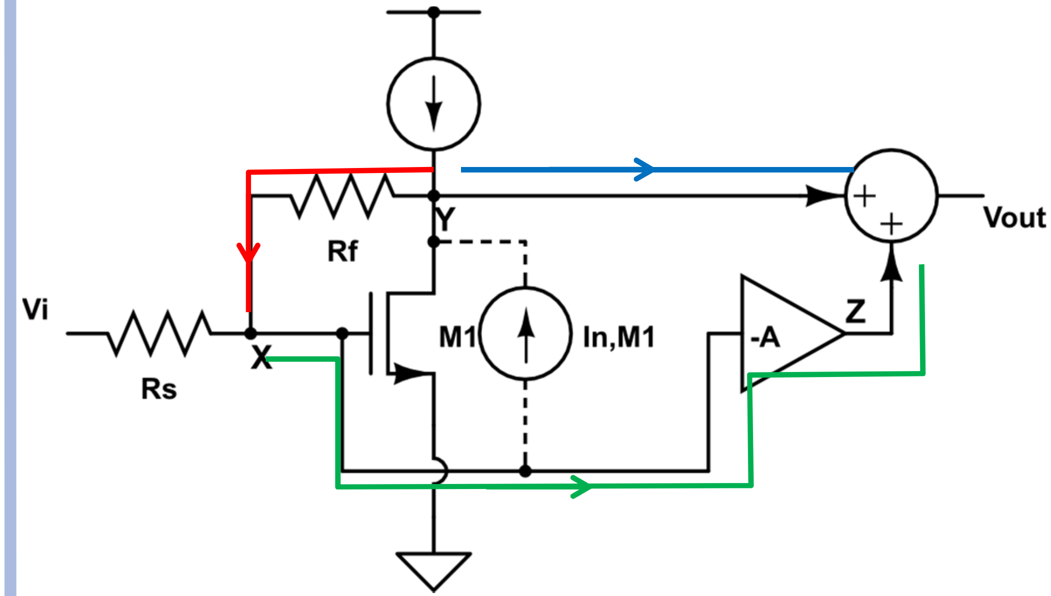
- LNA characteristics: matching, low noise, high gain.



Narrowband	Wideband	Wideband
Best noise	Poor noise	Poor noise
Large area	Moderate area	Large area

NOISE CANCELING TECHNIQUE

- Broadband matching and low noise
- Cancel matching stage noise



$$V_{n,X} = \alpha I_{n,M1} R_s$$

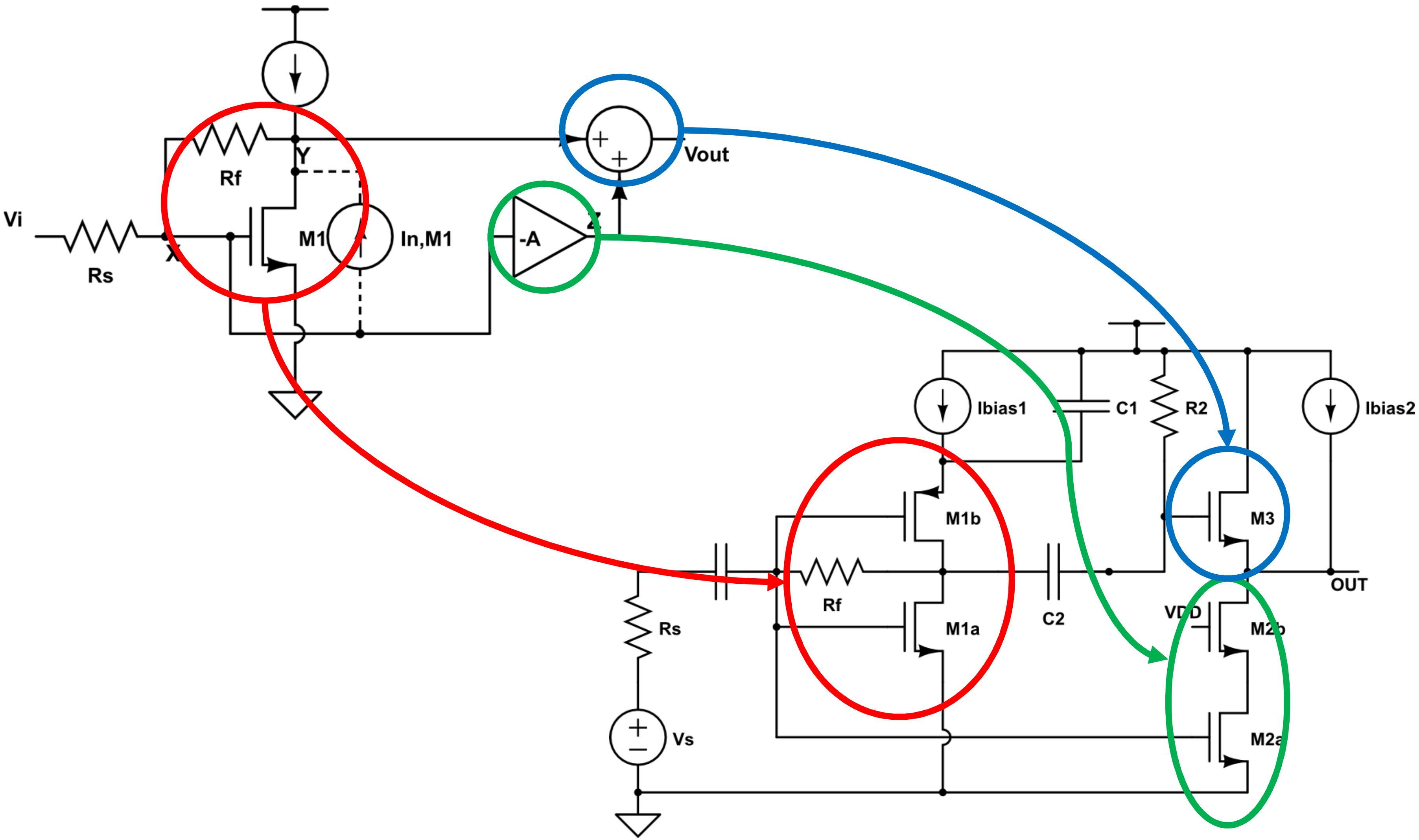
$$V_{n,Y} = \alpha I_{n,M1} \left(R_s + R_f \right)$$

$$V_{n,Z} = -AV_{n,X} = -A\alpha I_{n,M1} R_s$$

$$V_{n,OUT} = \alpha I_{n,M1} \left(R_s + R_f \right) - A\alpha I_{n,M1} R_s$$

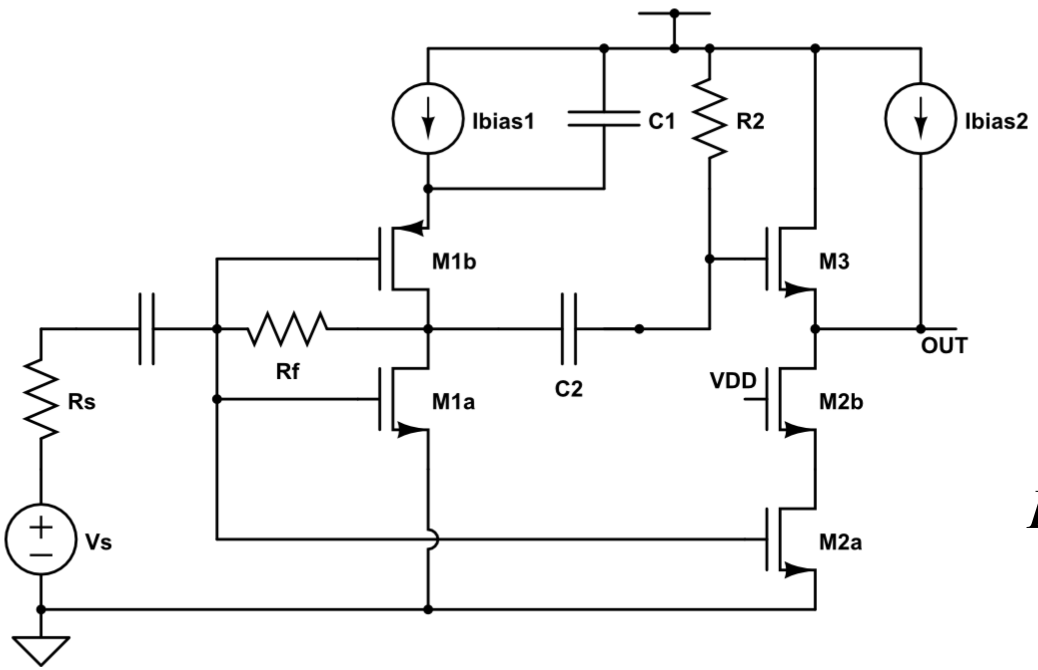
$$A = 1 + R_f / R_s$$

NOISE CANCELING TECHNIQUE



CIRCUIT DESIGN

- Inverter with feedback: better g_m.
- Cascode: better isolation.
- R2-C2: AC coupling.
- Bias: supply rejection, current bleeding.



$$R_{input} = 1/\left(g_{m1a} + g_{m1b}\right)$$

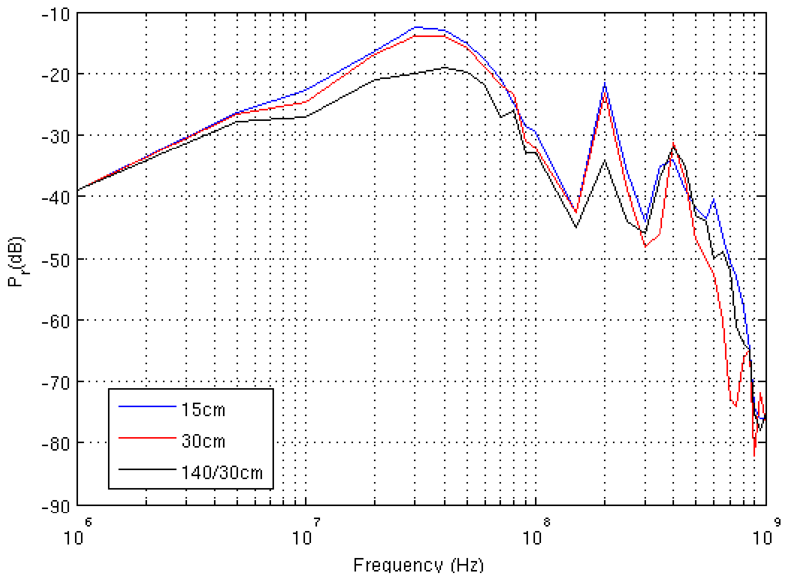
$$R_{output} = 1/g_{m3}$$

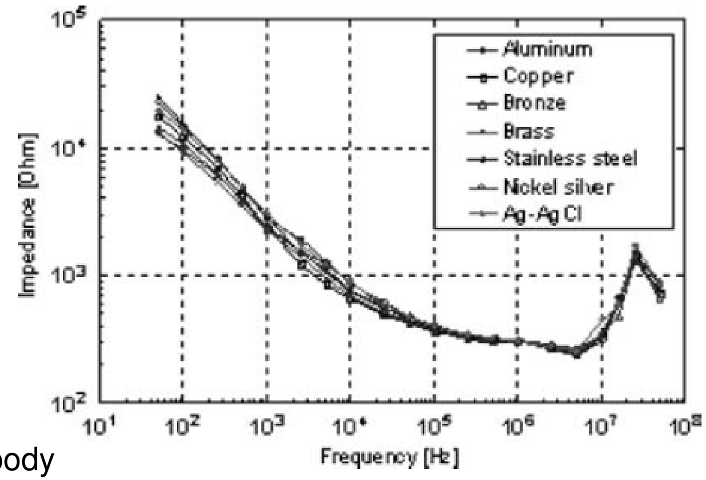
$$A = g_{m2}/g_{m3} = 1 + R_f/R_s$$

$$F = 1 + \frac{R_s}{R_f} + \left(\frac{1}{R_s} + \frac{3}{R_f} + \frac{2R_s}{R_f^2}\right)\frac{ENF}{g_{m2}}$$

CIRCUIT DESIGN

- Frequency:1-100MHz.
- NF = 2.5 dB
- Rin = 400 Ohms.
- Rout = 50 Ohms.
- Gain = 16dB.
- 180nm/1.8V

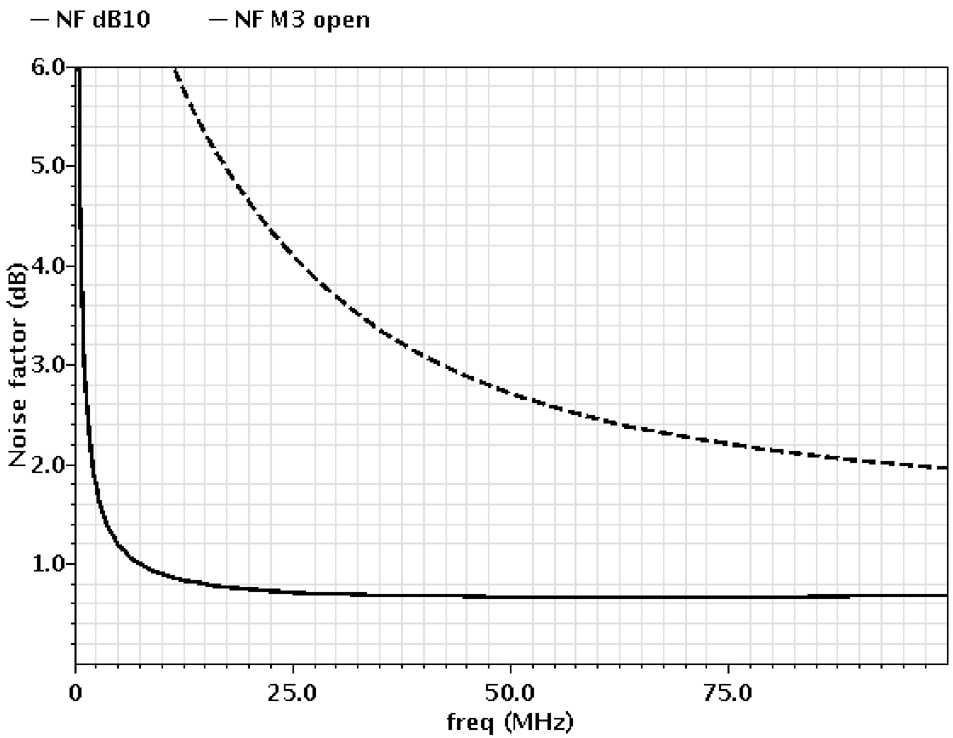


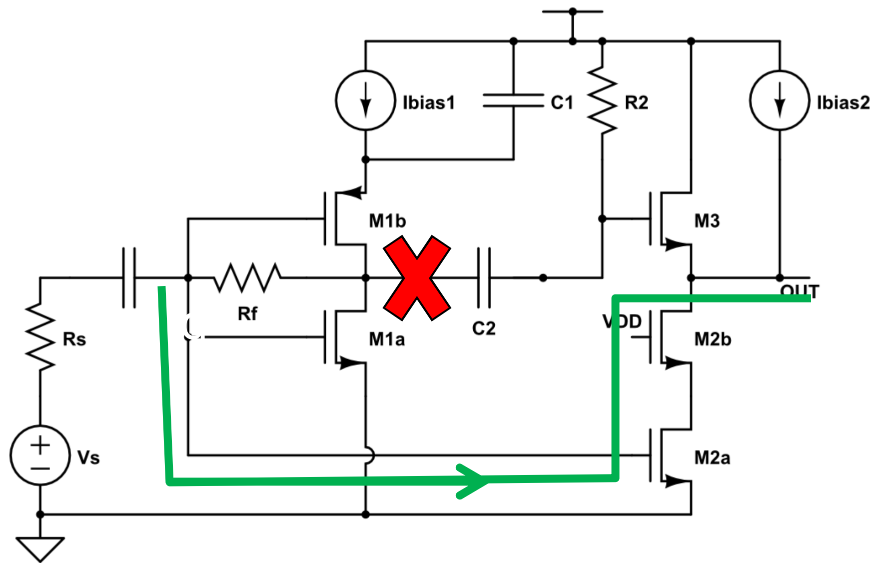


K. Hachisuka, T. Takeda, Y. Terauchi, K. Sasaki, H. Hosaka, K. Itao, "Intra-body data transmission for the personal area network", Microsystem Technologies, 2005.

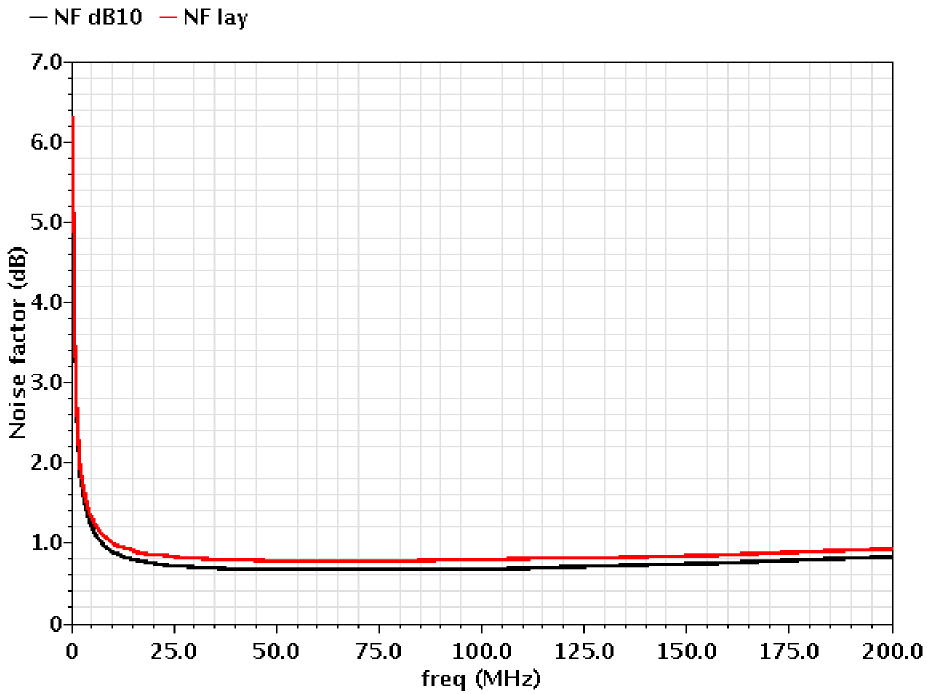
SIMULATIONS

- Noise canceling test.

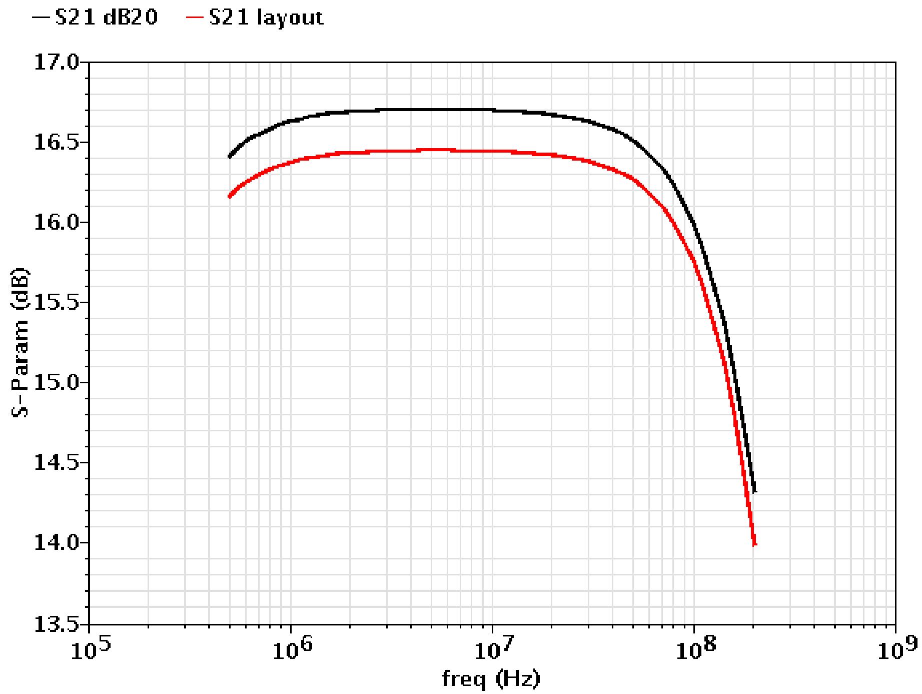




SIMULATIONS



NF



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SIMULATIONS

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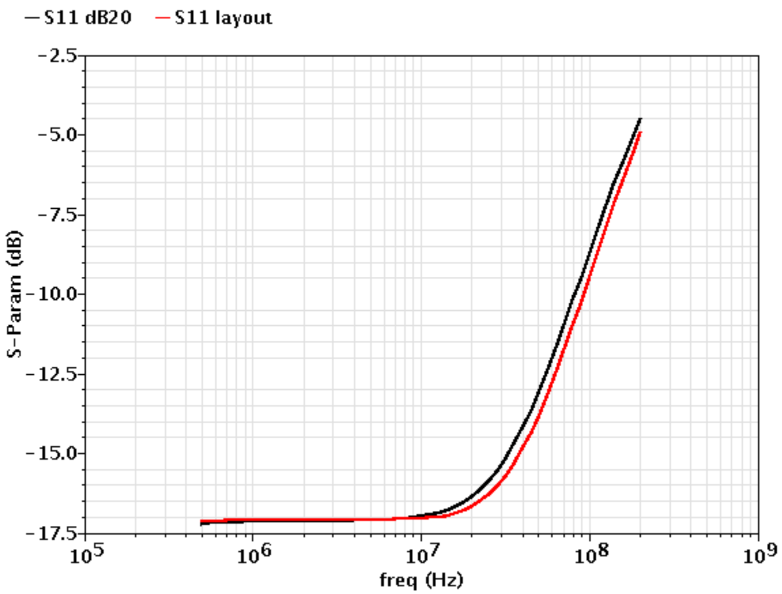

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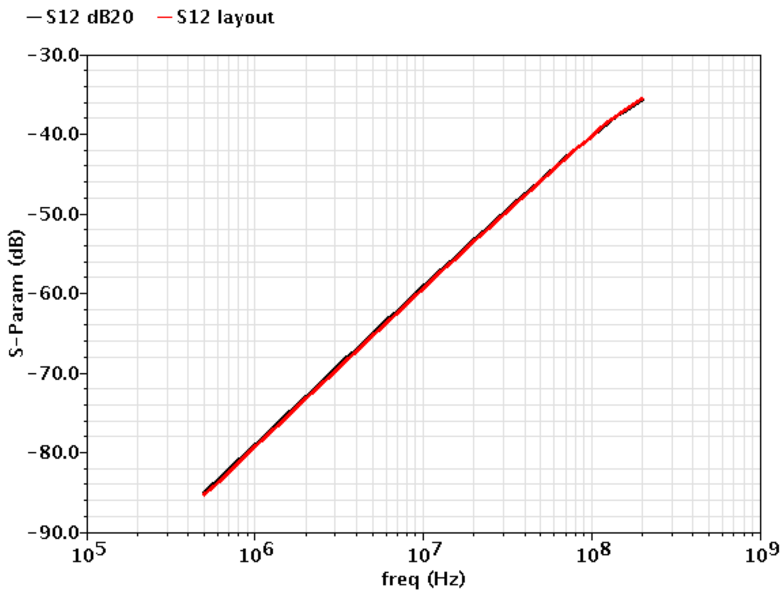

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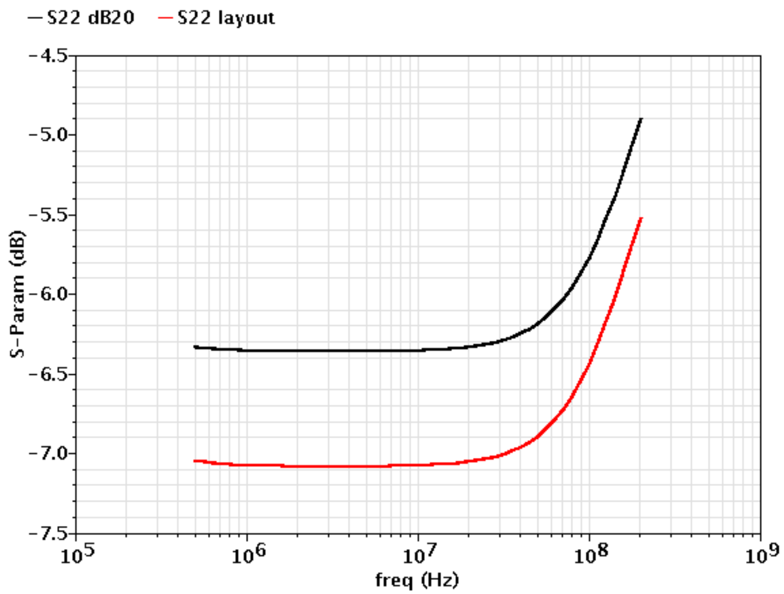

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SIMULATIONS

- Results summary for corners and Monte Carlo runs.

Corners	FF	FS	SF	SS	TT	MC Mean	MC Sigma
I_{dc} (mA)	11.09	10.49	9.70	9.26	10.07	10.03	0.42
NF (dB)	3.62	3.65	3.80	3.78	3.46	3.81	1.2
S_{11} (dB)	-8.74	-8.85	-9.88	10.05	-9.43	-9.43	0.80
S_{12} (dB)	-39.89	-39.27	-41.03	-40.49	-40.21	-40.22	1.20
S_{21} (dB)	17.60	17.85	13.84	14.17	15.75	15.58	1.88
S_{22} (dB)	-6.85	-7.38	-5.67	-6.03	-6.44	-6.46	0.88

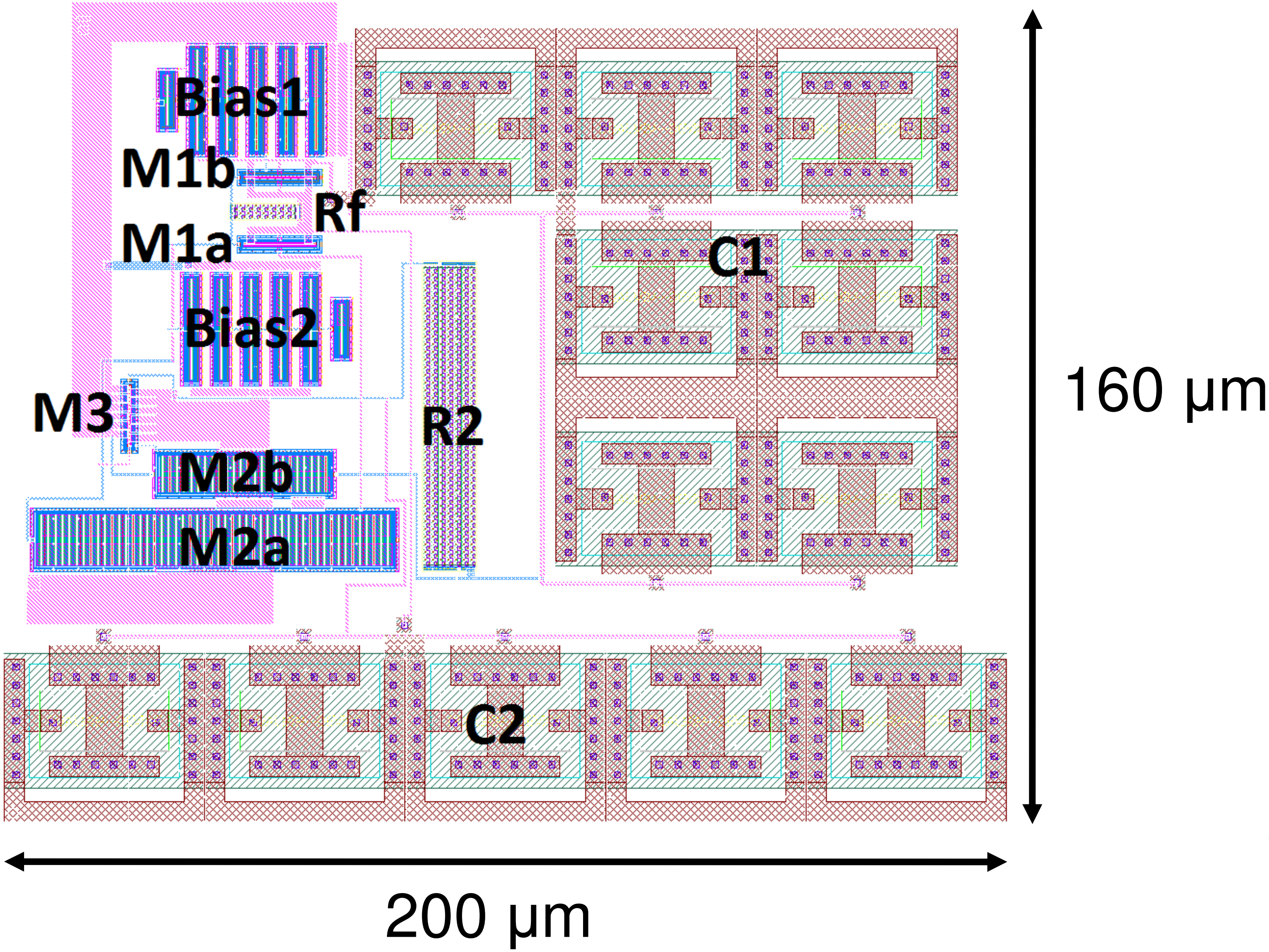
COMPARISON

Author	This work[1]	This work[2]	[10]	[11]	[13]	[14]	[16]
P_{dc} (mW)	18	18	2.16	0.6	35	18	17.46
NF (dB)	3.81	1.23	3	3	2.4	4.9	3.99
S_{21} (dB)	15.58	15.58	16	13	13.7	12.1	16.42
BW(MHz)	100	90	40	80	1600	1460	1490
f_c(MHz)	50	55	50	80	800	730	755
FOM(mW^{-1})	0.28	0.42	2.10	3.73	0.16	0.14	0.3

[1]BW = 1-100MHz, [2]BW = 10-100MHz $FOM = \frac{S_{21} . BW / f_c}{F . P_{dc}}$

[10] N. Cho, J. Bae, H. Yoo, "A 10.8 mW Body Channel Communication/MICS Dual-Band Transceiver for a Unified Body Sensor Network Controller", IEEE Journal of Solid-State Circuits, 2009.
[11] J. Bae, K. Song, H. Lee, H. Cho, L. Yan, H. Yoo, "A 0.24-nJ/b Wireless Body-Area-Network Transceiver With Scalable Double-FSK Modulation", IEEE Journal of Solid-State Circuits, 2012.
[13] F. Bruccoleri, "Wide-band low-noise amplifier techniques in CMOS" Thesis, University of Twente, 2003.
[14] K. Wang, K. Yeo, K. Ma, Z. Wang, “An Inductorless and Capacitorless LNA with Noise and Distortion Cancellation”, International Conference on Computer Research and Development (ICCRD), 2011.
[16] Y. Q. Wu, Z. G. Wang; J. Xu, L, Tang, "Wideband noise cancelling LNA with tunable active inductor for DRM/DAB receiver", International Conference on Microwave and Millimeter Wave Technology (ICMMT), 2012.

LAYOUT



CONCLUSION

- Noise canceling technique LNA
- Broadband low noise and matching
- Inductorless design
- Overall adequate performance for HBC

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Thank You